Intelligent Glasses: A New Man-Machine Interface Concept Integrating Computer Vision and Human Tactile Perception

Ramiro Velázquez, Flavien Maingreaud and Edwige E. Pissaloux

Laboratoire de Robotique de Paris, CNRS FRE 2507
18 Route du Panorama, BP 61
92265 Fontenay aux Roses, France
ramiro.velazquez@robot.jussieu.fr

Abstract. This paper introduces a new re-programmable interface concept, the *Intelligent Glasses (IG)*: an association of physiological human inspired machine vision and tactile stimulation for 3D (static and dynamic) world representation. The IG interface concept is used to design a wearable system to facilitate navigation and assist mobility of the low vision/sightless in 3D non-cooperating environments at the Robotics Laboratory of Paris (LRP) and the French Atomic Energy Commission (CEA). Being a re-programmable concept, the IG can be easily transferred to any system used in situations of limited or absent vision and/or systems requiring concise and high speed information representation (such as intelligent mobile robotics systems, surgical robotics, virtual reality, highly reactive interfaces, physiological studies of human perception systems, ..).

Keywords: Intelligent Glasses (IG), vision-tactile system, Electronic Travel Aids (ETA)

1 Introduction

Advances of technology and better knowledge of human physiological 3D world perception permit the design and development of new powerful and fast interfaces assisting humans in the execution of complex and difficult tasks.

Since their beginning, haptic interfaces (force and tactile displays) have been mainly associated with virtual reality environments. However, associated with vision, they present a potential solution to the problem of systems applied to situations where vision is limited or absent, and where concise and high speed information is required. Intelligent mobile robotics systems, highly reactive interfaces, ETA for mobility of the blind and the visually impaired are some examples of such systems. The last application is perhaps one of the most challenging.

Indeed, according to the 2002 monitoring report of the World Health Organization (WHO), there are currently close to 180 million people worldwide suffering from severe visual disability, 45 million of whom are totally blind. This census indicates that 7.4 million live in Europe and estimates that this number will double in the next twenty years as Europe becomes an aging society [1]. As a significant part of our society, the issue of the visually impaired represents a very important problem in terms of health and social security.

Of all sensations perceived through our senses, those received through sight have undoubtedly the greatest influence on perception. Sight combined with the other senses, mainly hearing, allow us to have a world global perception. For the visually impaired, the lack of sight and its “substitution” by hearing and touch provide unfortunately a world limited perception.

Therefore, there is an urgent need to determine how and by which technology is possible to best compensate the visually impaired, especially for deficiencies in spatial mobility. Human mobility is more than traveling from a starting to a destination point. Confronting a visually disabled to mobility requires spatial information of the immediate environment, orientation and obstacle avoidance; these seem to be essential to offer autonomy and most of all, safety.

Several devices have been developed for this purpose and are typically known as *travel aids* or *blind mobility aids*. The most successful and widely used are the walking cane and the guide dog. The walking cane, a purely and simple mechanical device, is an effective tool to detect static obstacles on the ground, uneven surfaces, holes and steps via simple tactile-force feedback. It is inexpensive, lightweight and portable. However, its “scan” range is limited (no overhanging obstacle detection, for example) and the user must be trained in its use with no guarantee to master the technique [2]. Guide dogs are very capable travel aids. However, they require extensive training, constant care and their price is far to be affordable. Furthermore, a dog is not capable of taking a decision in situations beyond its training [3].

Since the 1970s, the technology progresses have made possible the development of *Electronic Travel Aids* (ETAs). Most relevant examples are the C-5 Laser Cane [4], the Mowat Sensor [5], the NavBelt [6], the Guide Cane [7] and the Teletact [8]. Based on sonar-wave or laser-beam technology, these devices detect obstacles and provide their user-related position by means of acoustic feedback.

Although the great variety of ETAs available, none of these devices is widely used and user acceptance is relatively low. One of the main reasons of this rejection seems to be the quite small improvement achieved in comparison to classic travel aids (cane and dog). They obtain a 3D world perception via complex and time-consuming operations: local environment scanning is sequential, the gathered information should be memorized, analyzed and, once the decision has been taken… the environment has already changed !

Acoustic feedback has serious drawbacks, despite hearing represents the main sense for sightless people. Indeed, visually impaired strongly rely on hearing environmental cues. If acoustic information guides them through the environment, either all their attention is on these indications or it’s being shared between the environment’s information. In any case, there is a degradation or overload of the hearing sense.

Another problem is sensory saturation. Recent studies [9] have shown that a 20-30 minute usage of acoustic feedback devices causes serious problems to human sensors information registration, reduces human capacity to perform usual tasks and affects the individual's posture and equilibrium.

It may therefore be concluded that until now, no ETA has been built that can meet the demanding criteria of enabling an independent, efficient, effective and safe travel in unfamiliar and non-cooperating environments. A system providing a vision-like 3D world "quite" global perception using senses which are not usually involved, such as touch, could provide a significant improvement in 3D world perception for sightless and the visually impaired. The IG concept tries to provide such man-machine interface.

2 The IG Concept

The Intelligent Glasses (IG) is a new man-machine interface which translates visual data (such as a 3D global information) onto its tactile representation (cf. figure 1). The visual data is acquired and processed by a vision system, while its tactile representation is displayed on a touch stimulating surface.

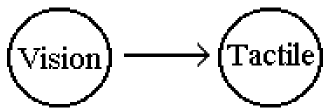


Fig. 1. IG main functional concept.

The visual data extracted from the environment varies according to the application context (a re-programmable vision system). For mobility tasks of the visually impaired, the fundamental data is obstacle detection and their spatial user-related localization. For object tracking tasks, the main data is coordinate localization of that object and its spatial tracking.

3 The Intelligent Glasses as a New ETA (IG-ETA)

The IG concept can be applied to design a new navigation platform to assist the displacement in 3D environments of the visually impaired by providing information on closest obstacles and available paths along a walking way.

Four classes of obstacles are expected to be identified: static obstacles located at ground level, static obstacles situated above ground level (i.e. hanging objects like branches), static obstacles below the reference level (like holes) and dynamic objects.

The system consists of a stereo vision non-calibrated camera configuration that acquires, encodes and transmits the environment's representation to a scene analyzer module. Vision algorithms are then applied in order to identify obstacles, their class and their user-related position. Finally, this information is transcoded into tactile sensory domain and displayed on a tactile interface for use by the visually impaired [10]. Figure 2 shows the IG-ETA general system structure.

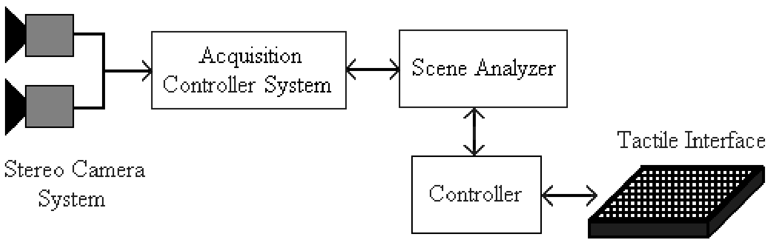
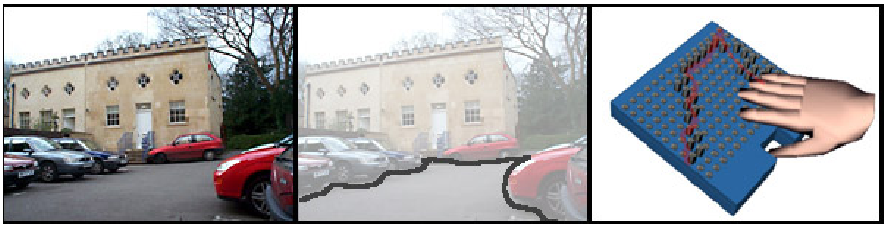


Fig. 2. IG-ETA system's global architecture.

Expected results to be obtained with the IG system are illustrated in figure 3: 3a) shows a mosaiced image obtained with the stereo vision system representing the immediate environment; 3b) shows how obstacles in the scene are identified via vision



a) b) c)

Fig. 3. IG-based ETA expected results: a) Mosaiced image obtained with the stereo vision system representing the immediate environment, b) obstacles in the scene are identified via vision algorithms and c) obstacles are displayed by the tactile interface letting know their location and thus, the available walking way.

algorithms and 3c) the obstacles are represented on the tactile interface letting know their spatial location (and thus the available walking way).

4 Conclusion

This paper has introduced the IG concept, a new man-machine re-programmable interface. 3D world vision gathered information is represented to the end user via a touch stimulation surface. The IG concept is currently being applied to design an electronic travel aid (IG-ETA) which purpose is to facilitate safe and independent mobility and navigation of the visually impaired, blinds and elderly people providing a simplified and fast 3D world representation. The IG-ETA concept enables static and dynamic, on/above/below reference level obstacle detection. The underlying principle of vision-tactile interaction could be easily transferred to other application domains like mobile robotics, intelligent robotics systems, surgical robotics, virtual reality, etc.

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